MANUFACTURE OF PURE CIDER VINEGAR IN THE UNITED STATES

BY
J. J. SCHOMMER

ARMOUR INSTITUTE OF TECHNOLOGY

1912

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A Thesis

Presented By

John J. Schommer

To the

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Approved

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Manufacture of Pure Cider Vinegar
In the United States.
PRINCIPAL PROCESSES.

Cider vinegar is a product from the alcoholic fermentation of the sugars of apple and subsequent oxidation of the alcohol to acetic acid. Cider vinegar forms the bulk of the table vinegar of the United States and Canada.

There are two processes in vogue for making pure cider vinegar; one is called the "Orleans" or slow process and the other is called the "Generator" or quick process. The former is practiced by farmers or those who use their product for home consumption. Very little finds its way into the market as it takes years to make. The latter is the common method employed by all manufacturers. By this process vinegar can be made in a few days. It is claimed for the Orleans process that it gives a vinegar with a better flavor and aroma than the Generator vinegar. But it takes a good vinegar maker to distinguish between the two when the Generator vinegar is pure and correctly made.

II.

CIDER STOCK.

In this country there are no apple orchards the fruit of which is used primarily for the purpose of vinegar manufacture. The apples constituting the bulk of the stock for vinegar manufacture are either "windfalls" or are so gnarled and specked as to prohibit their use for table purposes. There is still another source for cider stock and that is the cores and peelings left from apples used in the canning industry.

The apples are generally bought from the farmer by bushel and little attention is given to the variety. Many farmers have cider presses and thus press their own apples and subsequently sell their juice for sweet cider or sell it to the manufacturers to be made into vinegar.

The many varieties of apples fall under two general classes i.e., sour and sweet. It has been noticed in scientific investigations carried on by the government that for the same percentage of sugar in the two kinds that sweet apples give much nearer the theoretical yield of acetic acid than do the sour

or mixed varieties. It has been suggested that the greater percentage of malic acid in sour varieties over the sweet varieties interferes with the complete fermentation thus giving some foundation to a popular saying "Sour apples for cider and sweet apples for vinegar".

The following table shows the chemical composition of twenty five leading varieties of apples. The analysis were made by the government one to two months after the fruit was picked thus giving ample time for the residual starch to be converted into sugar. It may be seen that the total sugars, the valuable constituent for vinegar making, vary quite a little in the different varieties.

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Table V.

(Showing the chemical composition of twenty-five leading varieties of apples.)

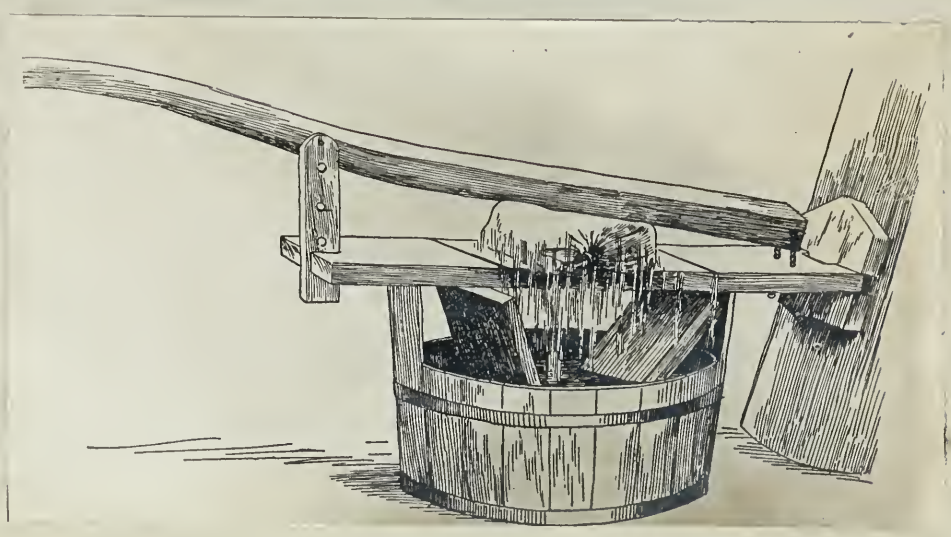
Number.	Variety.	Season.	Owner and Locality of Orcha
1	Red Astrachan,.....	Summer,	F.E.Tuttle,State College,Pa.
2	Early Harvest,.....	Summer,	College Orchard,State Colleg
3	Yellow Transparent,.....	Summer,	Geo.C.Butz,State College,Pa.
4	Early Strawberry,.....	Summer,	College Orchard,State Colleg
5	Sweet Bough,.....	Summer,	College Orchard,State Colleg
6	Butter-sweet,.....	Autumn,	College Orchard,State Colleg
7	Fall Rambo,.....	Autumn,	College Orchard,State Colleg
8	Baldwin,.....	Winter,	College Orchard,State Colleg
9	King,.....	Winter,	College Orchard,State Colleg
10	Golden Russet,.....	Winter,	College Orchard,State Colleg
11	Greening,.....	Winter,	College Orchard,State Colleg
12	Ben Davis,.....	Winter,	College Orchard,State Colleg
13	Northern Spy,.....	Winter,	College Orchard,State Colleg
14	Northern Spy,.....	Winter,	Geo.L.Watson, Clyde, N. Y.,
15	Spitzenburgh,.....	Winter,	College Orchard,State Colleg
16	Spitzenburgh,.....	Winter,	Mr. Hall, Clyde, N. Y.,
17	Twenty Ounce,.....	Winter,	Geo.L.Watson, Clyde, N. Y.,
18	Jonathan,.....	Winter,	T.W.Way, State College, Pa.,
19	Canada Reinette,.....	Winter,	T.W.Way, State College, Pa.,
20	Rambo,.....	Winter,	T.W.Way, State College, Pa.,
21	Newtown Pippin,.....	Winter,	Wm. P.Fisher, Unionville, Pa
22	Ewalt,.....	Winter,	Wm. P.Fisher, Unionville, Pa
23	York Imperial,.....	Winter,	Wm. P.Fisher, Unionville, Pa
24	Fallawater (Tulpehocken),.	Winter,	Wm. P.Fisher, Unionville, Pa
25	Yellow Bellflower,.....	Winter,	Wm. P.Fisher, Unionville, Pa
26	Sweet Vandevere,.....	Winter,	Wm. P. Fisher,Unionville, Pa
27	Bedford Red,.....	Winter,	Wm. P.Fisher, Unionville, Pa
	Average of all, ...	.....	.....

Number of apples taken for analysis.	Water.	Solids.	Invert sugar.	Sucrose.	Total sugar.	Total sugar after inversion	Free malic acid.	Ash	Sugar coefficient
10	84.70	15:30	6.67	3.53	10.20	10.38	1.11	0.37	67.84
10	83.82	16.18	7.24	3.84	11.08	11.28	0.87	0.31	69.72
4	86.17	13.83	7.84	2.05	9.89	9.94	0.84	0.27	71.87
10	84.42	15.58	5.34	4.11	9.45	9.66	0.76	0.28	63.00
6	85.18	14.82	7.51	2.98	10.49	10.64	0.10	....	71.79
6	85.70	14.30	7.97	3.62	11.59	11.78	0.38	0.19	82.38
6.	83.86	16.14	6.60	4.92	11.52	11.76	0.61	0.25	72.99
6	80.36	19.64	7.70	6.81	14.51	14.87	0.65	0.37	75.71
3	84.30	15.70	7.94	3.87	11.81	12.01	0.48	0.27	76.50
10	76.64	23.36	11.75	4.79	16.54	16.79	0.70	0.32	71.87
6	83.20	16.80	7.11	5.27	12.38	12.66	0.68	0.26	75.36
6	85.04	14.96	6.90	3.59	10.49	10.68	0.55	0.26	71.39
4	82.43	17.57	8.98	4.29	13.31	13.44	0.67	0.33	76.49
3	82.94	17.06	9.44	3.25	12.69	12.86	0.53	0.24	75.38
3	80.02	19.98	8.92	5.75	14.67	14.98	0.86	0.29	74.98
3	82.54	17.45	8.19	5.06	13.25	13.52	0.62	0.30	77.48
2	86.54	13.46	7.37	2.60	9.87	10.01	0.45	0.17	74.19
8	85.38	14.72	7.40	3.63	11.03	11.22	0.52	0.22	76.22
6.	85.62	14.38	6.60	3.74	10.34	10.54	0.51	0.24	73.29
8	84.30	15.70	10.32	1.74	12.06	12.15	0.36	0.23	77.39
6	82.39	17.61	6.36	6.13	12.49	12.81	0.80	0.37	72.74
6	84.36	15.64	8.13	2.64	10.77	10.91	0.99	0.26	69.76
6	82.90	17.10	8.65	4.33	12.98	13.21	0.46	0.22	77.35
6	84.69	15.31	8.51	3.08	11.59	11.75	0.32	0.22	76.75
6	81.68	18.32	8.43	4.65	13.08	13.32	0.74	0.34	72.71
6	82.25	17.75	8.81	3.85	12.66	12.86	0.26	0.30	72.45
4	84.96	15.04	7.40	3.50	10.90	11.08	0.66	0.28	73.67
...	83.57	16.43	7.92	3.99	11.91	12.12	0.61	0.27	73.76

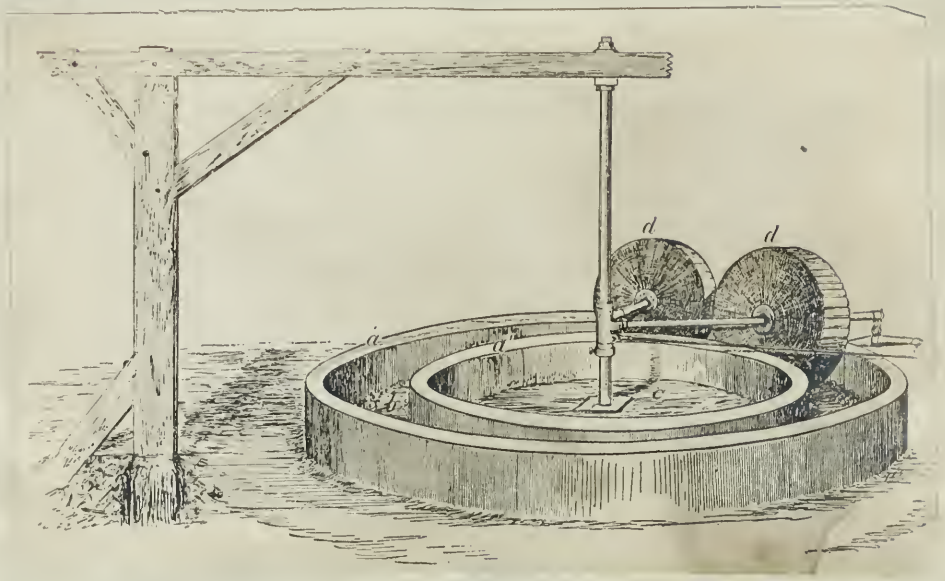
PREPARATION OF THE STOCK & PRESSING.

The apples are piled in heaps on the ground and are generally without protection from the elements. The apples are washed thoroughly with water and then run through the press. The presses in vogue are the screw type, double acting ratchet, and the modern hydraulic. The fruit is subjected to 50 to 100 tons pressure for some time. Amongst the farmers who use their product for home or local consumption, and the small manufacturer behind the times the more primative types of presses are still used.
Cuts of these are shown.

The result of this pressing is the sweet apple juice and the pulp or pomace. The former is sent to the fermenting tanks while the latter is piled in heaps. When the pomace can not be sold as a fertilizer or for feed, many of the manufacturers pay to have the refuse, as they are wont to term it, hauled away. Some of the people alive to the possibilities of this refuse pomace are finding other uses for it. It is claimed by the Virginia station, with their 80 ton modern hydraulic press, with the very



Hand Press



Press Worked by Hand or Horses

Press Worked by Hand or Machinery

best conditions, that but 74% of the weight of fruit is recovered as juice and that 70% is very high.

Analysis by the government showing the chemical composition of apple juice is shown in table 2.

Table 2.

Number	Variety	Season	Specific gravity	Solids.	Invert sugar.
1	Red Astrachans,.....	Summer	1.05317	12.78	6.87
2	Early Harvest,.....	Summer	1.05522	13.29	7.49
3	Yellow Transparent,	Summer	1.05020	11.71	8.03
4	Early Strawberry,...	Summer	1.04949	11.81	5.47
5	Sweet Bough,.....	Summer	1.4979	11.87	7.61
6	Baldwin, green,.....	Winter	1.04882	11.36	6.96
7	Baldwin, ripe,.....	Winter	1.07362	16.82	7.97
8	Ben Davis,.....	Winter	1.05389	12.77	7.11
9	Bellflower,.....	Winter	1.06270	14.90	9.06
10	Tulpahocken,.....	Winter	1.05727	13.94	9.68
11	Unknown,.....	Winter	1.05901	13.75	10.52

Sucrose	Total Sugar	Total Sugar after Inversion	Free Malic Acid	Ash	Undetermined (pectin) (etc.)	Rotation 400 mm. tube Vntzke scale. Degrees to the left
3.63	10.5o	10.69	1.14	0.37	0.77	23.72
3.97	11.46	11.67	0.90	0.28	0.65	24.32
2.10	10.14	10.24	0.86	0.27	0.44	.....
4.21	9.68	9.90	0.78	0.24	1.11	19.24
3.08	10.69	10.85	0.10	....	....	39.40
1.63	8.59	8.68	1.24	0.31	1.22	36.16
7.05	15.02	15.39	0.67	0.26	0.87	.....
3.85	10.96	11.16	0.46	0.28	1.07	49.00
4.32	13.38	13.61	0.88	0.28	0.66	39.20
3.11	12.79	12.95	0.26	0.24	0.49	48.20
2.31	12.83	12.95	0.44	0.26	0.22	44.18

FERMENTATION.

The juice, is placed in large fermenting vats, and, from the yeasts present aided by those falling or finding their way into the vats, is fermented to alcohol. Yeasts from the genuis Laccharomyces do the fermenting. The sugars in the apple are changed into alcohol and carbonic acid according to the general formula.

C-6, H-13, O-6, $\longrightarrow$ 2 C-3, H-5, OH + 3 CO-2, or 100 parts of sugar give 51.11 parts alcohol and 48.89 parts carbonic acid. This is the theoretical yield but only about 93% of this is obtained in practise, according to the work done at the Pennsylvania Experimental Station. The sucrose present is not directly fermentable but by means of invertase, a soluble ferment, which exists in some yeasts, is changed to dextrose and levulose; these sugars are then converted into alcohol and carbonic acid.

Besides these main products, varying amounts of glycerine, acetic, succumic, lactic, and butryc acids are formed. These by products and their quantity de-

pend on organisms present and on the temperature of the fermentation. These alcoholic ferments or yeasts have an optimum temperature for growth and this has been determined to be 18° to 24° C (65 to 75° F). This temperature produces a rather violent fermentation. Temperature control should play an important part in the fermentation but little attention is paid to this phase of the manufacture as a natural fermentation is relied on.

The alcoholic liquor is now ready for either the Orleans process or the generator process.

Table 3 shows the chemical composition of fermented ciders.

Table 3.

Number.	Variety of Apples.	Specific gravity.	Solids.	Invert sugar.	Malic acid.	Acetic acid.	Alcohol
1	Mixed,..	0,99805	1.94	0.19	0.81	0.84	6.85
2	Mixed,..	1,00133	3.71	0.19	0.84	0.42	5.13
3	Mixed,..	1.00585	3.86	0.89	0.30	0.48	4.67
4	Mixed,..	1,00071	1.93	0.34	0.87	0.81	4.95
5	Mixed,..	1.00512	3.71	0.34	0.89	1.96	4.86

Pectin.	Ash.	Rotation 400 mm tube Ventzke scale. Degree to left.
0.03	0.35	2.30
0.03	0.38	2.49
0.05	0.29	5.28
0.05	0.23	3.00
0.06	0.36	1.76

ORLEANS PROCESS.

The Orleans process of vinegar making consists of taking this alcoholic liquor and transferring to large casks kept in a room with temperature about 75° to 85° F. At this temperature the acetic fermentation will proceed best. It may be allowed to stand with the bung open and the cask at three-quarters full (In fact casks should not be more than a half to three-quarters full) and be subjected to spontaneous fermentation. But generally to hasten the process the liquor is inoculated by adding "mother" or by mixing with old vinegar. This "mother" or "mycoderma aceticˮ consists of a felt-like scum which commonly forms on the surface of cider vinegar. Different micro-organisms are found in this "mother" and several distinct species capable of bringing about the acetic fermentation have been isolated. This film or mother exercises the greatest activity at 35° C. and ceases to act at 40° C. and further the film can not react in the presence of more than 14% alcohol. Pasteur showed that acetic acid generated by oxidation is transformed if the oxidation is

complete into CO-3 & H3-O. This has been confirmed by Adrian J. Brown. This is due to a bacteria (Bxylinum Brown), which in the presence of oxygen splits up the acetic acid. Thus when maximum yield of vinegar is reached it should be drawn off.

A whole series of species belonging to the vinegar ferments are now recognized. It is hardly necessary to enumerate them as still much work remains to be done to utilize them as a pure culture in the Orleans process of vinegar manufacture owing to the difficulty of control.

The most important advance in our knowledge of acetic acid bacteria was made several years ago when Buchner and Meisenheimer as well as Herzog proved that this acetic fermentation was brought about by the activity of enzyme. The cells may be killed with acetone and then treated in the same way as the alcohol yeasts - namely: A crushing and grinding and treating with reagents - and after evaporating the liquid, the residue can bring about the acetic fermentation although it contains no living cells. Like the alcoholic fermentation, which is caused by an enzyme so is the acetic

fermentation.. In other words the conversion of alcohol to acetic acid is facilitated by catalytic action.

Another method of converting the alcoholic liquor to acetic acid is effected by the addition of successive portions of this liquor to a cask impregnated with "Mother". Two to four gallons are added from time to time and when the cask is about half full one third of the vinegar is withdrawn and put in other tanks to complete its fermentation. This is kept up till the "Mother" tank is too full to proceed further. The sediment is then washed out and the "Mother" subjected to washing and is again used to start fresh fermentations. The essential physiologic requirement of acetic fermentation is an abundant supply of oxygen. Without it the conversion of alcohol to acetic acid cannot take place.

It requires a week to ten days for the conversion of the sweet apple juice to the alcoholic liquor. Then for the oxidation of this liquor to acetic acid it requires from fifteen to thirty months by the "Orleans"

Casks for Orleans Process

or "slow process". It is claimed for this process that a better vinegar is produced than can be made by the generator method. The delicate and volatile esters which give vinegars their peculiar properties are said to be products of a less violent and slower fermentation. These esters give the vinegar an agreeable aroma and boquet hard to equal by the "quick process". But the generator vinegar when made correctly is just as palatable as the other and is not easily distinguished from the same unless one is quite skilled in judging vinegar.

(B)

THE GENERATOR PROCESS.

The great length of time required by the cask fermentation lead to the adoption of the vinegar generator by means of which the alcoholic liquor may be converted into acetic acid in the course of a few hours.

The generator consists usually of an upright cask or vat about twelve feet high and five feet in diameter. A perforated false bottom is fastened about fifteen inches from the bottom of the cask. Upon this beech-wood

shavings are placed until the cask is nearly full. The shavings, before using, should be boiled thoroughly, then dried and soaked in old vinegar for several hours. In the use of the pure culture system the shavings would be innoculated with a good strain of acetic bacteria. The purpose of the shavings is to spread the liquid into very thin films or small drops thus aiding in rapid oxidation. The shavings also serve as place for the attachment of the ferment. A perforated disc is placed over the shavings and a dumping apparatus placed over this and then lastly the cover, with a vent to admit the alcoholic liquor. The dumping apparatus is a scoop arrangement placed on an axis; a scoop on each side of an axis.

The liquor entering the vent drops on one side of the scoop until it becomes so heavy as to rotate on the axis and thus dumps the vinegar on the perforated disc and it then trickles thru the shavings. The other scoop now fills up and goes thru the same process falling on the opposite side of the first. The vinegar by the aid of this dumping apparatus is distributed evenly.

Just under the perforated disc, which is placed about fifteen inches from the bottom, holes from the outside of the cask are bored in and slanting downwards. These holes are for the purpose of admitting oxygen and are slanted downwards to prevent the vinegar, which after its course thru the generator falls into the space between the bottom and the perforated discs, from trickling out.

These generators are placed in series one above the other. Three in a series, one above the other, is good practice. The vinegar generators are placed in long rows and the top of the series is fed from a large supply tank into which the alcoholic liquor is pumped with a bronze piston. Bronze seems to last longer than any of the other metals in a vinegar factory.

When everything is ready for the admittance of the cider it is then run out of the supply tank and mixed with strong vinegar. The alchholic liquor mixed with strong vinegar enters the vent at the top of the generator; is dumped one way and then the other, the vinegar running over the top of the perforated disc -

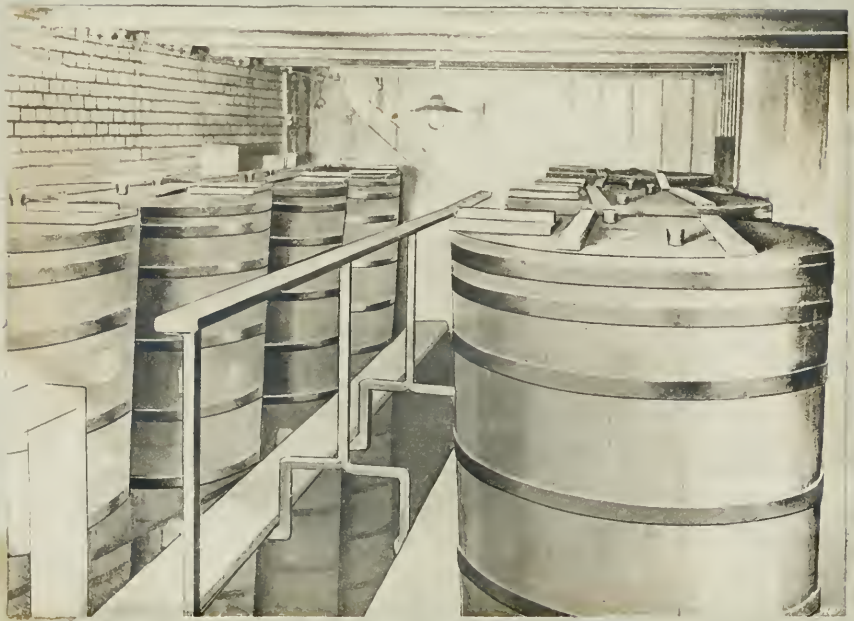
thus being evenly distributed, and slowly drips thru the disc on to the beech wood shavings. Here it comes in contact with the ferment(which was added by soaking the beech wood shavings in strong vinegar) and, with a current of air passing up is, by the catalytic action of the enzyme of acetic bacteria, rapidly oxictized to acetic acid. The rate of flow depends primarily on the temperature and on the size of the generator. In winter the generators are run much faster than in the summer. As a general rule the rate of flow thru the generator should not be faster than a gallon an hour. The first generator never completly oxidises the alcohol nor does the second. The liquor by gravity is run thru the three generators.

During the oxidation of the alcohol considerable heat is generated causing the air to rise and to escape thru the vent in the top. This produces a good circulation of fresh air entering the holes just below the false bottom and rising up thru the generator. The temperature of the generator is observed from time to time by means of a thermometer inserted in the shavings thru a hold half way up the cask. A temperature of

about 95° F secures the best results. If it is much above this temperature the heat will cause an appreciable loss of alcohol whereas a heat much below this degree prevents the acetification from proceeding properly. Too rapid a current of air evaporates the alcohol. Sometimes heat is generated to such an extent that the beech wood shavings blacken and the efficiency of the generator is so imparied that it must be cleaned out and a new charge of beech wood shavings put in.

The temperature of the generator is regulated by the supply of air entering the holes just below the false bottom. To reduce the temperature the supply of air is cut off by plugging the holes; this reduces the oxidation and therefore the temperature. To raise the temperature the supply of air is increased.

Strict watch must be kept when cider vinegar is being run thru the generators. A very exact regulation of the strength, flow of alcoholic liquor, and of the amount of air admitted is highly essential..If the generators are running too cold the vinegar comes out with



Generators

too much alcohol and therefore must be pumped up and run thru the generators again. This always entails some evaporation. If air is run thru too fast the generator may not only "burn up" (beech wood shavings char.) but an enormous evaporation of alcohol results. Pure air and good ventilation are also necessary. Sometimes when opportunity is favorable Bacterium Xylinum contaminates the generators. This bacteria resembles the strains of acetic bacteria but has an evil effect on the generator and the vinegar. It forms a film the slime of which becomes gristles cartilaginous and tough like leather. It acts unfavorably on the aroma of vinegar and by forming the slime often arrests the quick vinegar process. If vinegar eels, which produce slime, appear they are killed with hot vinegar.

There should be a small amount of alcohol left in the vinegar when it comes out of the generator. If it is all converted mal organisms and oxidation may decompose the acetic acid to carbon dioxide and water. Also there should be in the vinegar when barreled a small portion some 2 or 3% alcohol so that it may slowly be transformed into acetic acid. It appears that this decomposition process is instituted only after all the

alcohol has been changed into acetic acid.

The product of the quick process is more uniform in composition than that obtained by the Orleans process. This is due to the fact that the conditions affecting the acetification are more easily controlled. This method of generating vinegar lends itself easier to the use of pure culture than does the Orleans Process. This will be taken up later under another head.

Table number shows four samples of pure apple cider vinegar analysed by the Dept. of Agriculture of the State of Pennsylvania.

Number.	Maker.	Kind of apples.	Specific gravity.	Solids.
1	W. C. Patterson, State College, Pa.,	Mixed,	1,01550	1.44
2	W. P. Fisher, Unionville, Pa.,	Mixed,	1,01425	1.75
3	W. P. Fisher, Unionville, Pa.,	Mixed,	1,01625	2.10
4	W. P. Fisher, Unionville, Pa.,	Sweet Vandevere,	1,02750	2.72

Acetic acid.	Pectin.	Ash.	Invert sugar.	Rotation 400 mm tube Ventzke scale Degrees to left.
6.23	0.09	0.30	0.47	3.01
4.33	0.13	0.43	0.20	0.96
4.26	0.19	0.48	0.67	2.27
9.96	0.25	0.57	0.75	2.94

The following analysis was made by the writer, of a pure cider vinegar. The apples were raised in Michigan and picked in the Fall of 1911 and converted to cider vinegar by the Spielmann Bros. Vinegar and Yeast Company. The president of said concern, Mathias Steffen, with affidavits of his vinegar maker attested to its purity. The writer made the analysis in the Spring of 1912 according to the Methods given in Leach's Food Inspection and Analysis, and according to a recent method employed by the government in the analysis of vinegar for glycerine.

	gms per 100 CC.
Specific Gravity	1.0160
Acidity	6.47%
Ash total	.40%
Soluble ash	.352%
Insoluble ash	.048%
Alkalinity of soluble ash N-10 HCE 100 CC	48.9
Solids	2.65%
Soluble P-2, O-5 mgs. per 100 CC	19.7
Insoluble P-2, O-5 mgs. per 100 CC	12.6
Total P-2, O-5 in ash	32.3
Fixed acid as Malic	.019
Precipitate with neutral cad acetate flocculent and heavy settling out well	
Alcohol	none
Sugars	32.5% T.S.
Non Sugar solids	1.80%
Sugars	.86%
Ratio of ahs to non sugars	1 to 4.5
Glycerine	.336
Polarization direct Temperature	20° - 0.7

The following is an analysis made by H. C. Lythgoe in Mr. Leach's Laboratory, Author of Leach's Food Inspection and Analysis. Result tabulated is the analysis of twenty-two samples of cider vinegar of known purity.

	Acid Acetic	Total Solids	Ash	Alkalinty of Ash	P-3,0-5 A Shop, 100 gms Vinegar. Soluble Mgs.	Insoluble Mgs.
Maximum	5.86	3.20	0.42	36.1	31.7	31.5
Minimum	3.92	1.84	0.20	22.2	12.1	6.6
Average	4.84	3.49	0.34	29.7	19.2	15.6

	Reducing sugars before Inversion.	After Inversion	Polarization Pe-gress Ventzke 200mm tube.	Malic acid.
Maximum	0.51	0.53	-3.6	0.16
Minimum	0.15	0.15	-0.3	0.08
Average	0.25	0.25	-1.3	0.11

It will be seen that the pure cider vinegar manufactured by the Spielmann Brother's Company conforms well with the analysis made by others interested in the subject. There are many spurious cider vinegars on the market but the manufacture of these is beyond the writer's subject.

The only comment the writer has to make on the government's standards for purity is on the glycerine test. The

principal products of alcoholic fermentation of sugars of course are ethyl alcohol and carbon dioxide. Pasteur showed that by-products always occur and named them.. Amongst these by-products he named glycerine. The writer was unable to find any literature pertaining to glycerine in cider vinegar.

Wortmann and Laborde in their tests for glycerine in nutritive liquids fermented by yeasts found that the decomposition of nutritive liquid did not determine the quantity of glycerine but the quantity depended particularly upon the yeast species. Its production is favored by high temperature and by a rich nutritive liquid. In wine musts and other nutritive substances it is a well known fact that different yeasts give varying amounts of glycerine when allowed to ferment the same substance. Lafar found while investigating influence of acids especially acetic acid on wine musts that not only the amounts of alcohol and carbon dioxide produced varied but also the amount of glycerine varied. Since temperature and specie of yeast have some influence on the amount of glycerine formed in nutritive liquids containing saccharose or invert sugars, it is not

unreasonable to suppose with the system of spontaneous fermentation employed in converting the sweet cider to an alcoholic liquor that varying amounts of glycerine would be produced from year to year. The fermentation is carried out in the open and yeast spoores inherent in the liquid or yeast spoores dropping in from the air carry on the fermentation. It is a well known fact that at one temperature a specie of yeast may be active while at an other time it may be dormant. It is unreasonable to suppose that every year the temperature in the fall of the year at the time the fermentation is taking place will be the same or will be the same in all localities that the cider vinegar is made. Also it would be unreasonable to suppose that the same specie of yeast was doing the fermenting in the different localities. Also according to the temperature in the same locality the specie of yeast having the upper hand throughout the fermentation would likely differ from year to year. Thus it would seem that the government would have to set a glycerine minimum standard every year and that this standard must be set from practical results obtained from the analysis

of a large number of samples of vinegar made in the various vinegar producing regions in the United States. Unless the government does set the standard based on the above it will undoubtedly work a hardship on some pure cider vinegar manufacturers.

Again in generating the vinegar acetic acid bacteria may decompose the glycerine Henneberg found numerous substances which can be converted into acids by the various species.

	Bact. industrium.	Bact. oxydans.	Thermobact-aceti.	Bact. acetosum.	Bact. Kutzingianum	Bact. Pasteurianum.	Bact. Acetigenum.	Bact. Ascendens.	Bact. Xylinum.
Arabinose	+	+	-	-	-	-	-	-	-
Levulose	+	+	-	-	-	-	-	-	-
Dextrose	+	+	+	+	+	+	+	-	+
Galactose	+	+	-	-	-	-	-	-	-
Saccharose	+	+	-	-	-	-	-	-	slight
Maltose	+	+	-	-	-	-	-	-	-
Lactose	+	slight	-	-	-	-	-	-	-
Raffinose	+	+	-	-	-	-	-	-	-
Dextrin	+	+	-	-	-	-	-	-	-
Starch	+	-	-	-	-	-	-	-	-
Ethyl Alcohol	+	+	+	+	+	+	+	+	+
Propyl Alcohol	+	+	+	+	+	+	+	+	+
Glycol	+	+	+	+	+	+	+	+	+
Glycerine	+	+	-	-	-	-	-	-	
Erythrite		+		-	-	-	-		
Mannite	+	+	-	-	-	-	-	-	-

The above table shows that two species i.e., Bact. industrium and Bact. oxydans do decompose glycerine. There undoubtedly other species not yet isolated or species known that have not been tried on glycerine that will also decompose glycerine.

Since the generation of vinegar by the "quick process" is not on a pure culture basis this decompositionmight very easily be effected.

The writer attempted to isolate glycerine treating the cider vinegar by the method chosen by the government for the determination of glycerine. Some forty gallons of the vinegar whose analysis is herein given as analyzed by the writer were used in the attempt. Large stoneware (glazed) acid resisting evaporating dishes of sixteen gallons capacity were used. These dishes were placed on steam kettles. A Photograph of the arrangement is shown. The temperature in the dishes was kept at about eighty degrees. The experiment was terminated by the writers graduation ere any results of value were attained.

Preventing Wastes in the Manufacture of Cider Vinegar.

The buying and handling and handling of the apples is of some importance and should receive considerable more attention than is paid to it. Instead of paying alike for all varieties, more careful discrimination should be exercised. For the same sugar content in the sweet and sour varieties, the former kind produces much nearer the theoretical yield of vinegar than does the latter. Further, the buyers should strive to get the varieties that produce the greater sugar content. Again, ripe fruit should be striven for. The following table shows the analysis of the Baldwin apple by C. A. Brown, shows the changes that take place during ripening:

Period.	Date, 1899.	Condition.	Water.	Solids.	Invert sugar.
I.	Aug. 7	Very green	81.53	18.47	6.40
II.	Sept. 13	Green	79.81	20.19	6.46
III.	Nov. 15	Ripe	80.36	19.64	7.70
IV.	Dec 15	Over-ripe	80.30	19.70	8.81

Sucrose	Total Sugar	Total Sugar after Inversion	Starch	Free Malic Acid	Ash	Sugar Coeffi-cient
1.63	8.03	8.11	4.14	1.14	0.37	47.16
4.05	10.51	10.72	3.67	....	....	53.10
6.81	14.51	14.87	0.17	0.65	0.37	75.71
5.26	14.07	14.35	....	0.48	0.28	72.84

Apples before being pressed should lay on flooring off the ground and be allowed to ripen two or three weeks to convert all the starch possible into sugars. Again, apples should not be left too long after ripening. Any rottening caused by malorganisms causes a loss of sugars. Following table shows an analysis of the sweet Vandere apples during after ripening. Analysis was made by C. A. Brown:

Period	Date 1899	Water	Solids	Invert Sugar	Sucrose	[illegible]
I.	Nov. 27	82.25	17.75	8.81	3.85	12.66
II.	Dec. 15	81.65	18.35	9.61	3.18	12.78

It will be noticed if the 12.95% of total sugars after inversion in II be calculated to the original weight of apples there would be found only 12.09% or a decrease of 0.77% from the amount originally present.

Total sugar after inversion.	Malic acid.	Ash.	Sugar coefficient.	Loss from evaporation.
12.86	0.26	0.30	72.45	.....
12.95	0.26	0.34	70.57	6.66

FERMENTING THE FRUIT

Apples with the present system of fermenting should not be washed unless they be so dirty that it is an absolute necessity. The washing rids the apples of the inherent yeasts that the spontaneous fermentation of the sweet cider relies on.

The proper way to do the fermenting is in large closed vats and inoculating the liquor with a well selected variety of yeast from the saccharomyces' family. With large vats and consequently large amounts of liquor, the fermentation may be better controlled and is much less susceptable to atmospheric changes. Vents for the outlet of air may be lead into sulphuric acid thus preventing entrance of undesirable organisms to contaminate the liquer. In this way the liquors fermented in various vats would have more nearly a uniform composition

PRESSING THE FRUIT

In pressing there is a big waste. The Virginia station claims that 70% of the juice obtainable is high. The Virginia station uses an 80 ton hydraulic

press. C. A. Brown claims that but 70 to 80% of the obtainable juice is extracted by the present methods in vogue. In Germany, for cider stock, some concerns shred their apples, put the shreds in cheesecloths and then subject the cheeses to hydraulic pressure. It is claimed a higher efficiency for this method. The method for higher efficiency probably lies in the preparation of the apples before pressing than in bettering the press.

POMACE.

Pomace in most cider factories was treated similar to the way sawdust was treated in our lumber mills but a few years ago:- burned up, thrown away or given away. Pomace has been tried as a fertilizer. The proportion of nitrogen, potash and phosphoric acid amounting to but $.50 to $1.00 to the ton does not make it worth handling. It has been used for feeding stock but most farmers will use it so only when paid to haul it away. A profitable way of handling it it to leach it with warm water and ferment it with a yeast and then distill the fermented liquor.

It may be repressed after a slight addition of water. The pressed juice from this second pressing may be then evaporated for jelly or allowed to ferment for vinegar stock. A better method is to run the juice of the first and second pressings down in an evaporator for jelly stock. The manufacture of jelly from the second pressing may be made a large item of profit. The residue even of the second pressing may sometimes be treated to advantage, especially so if a poor press is being used.

The following table shows the chemical composition of first and second pressings made by the government.

	Specific Gravity	Solids	Invert Sugar	Sucrose
Second pressing	1.03764	9.14	7.13	1.33
First pressing	1.05901	13.75	10.52	2.31

While the second pressings show to be inferior to

Total sugar.	Total sugar after inversion.	Ash.	Rotation, 400 mm tube, Ventzke scale. Degrees to left.
8.46	8.53	0.20	31.94
13.83	13.95	0.26	44.18

that of the first it is nevertheless valuable. From this second pressing may be made a cider with 4% alcohol and a vinegar of equal strength. This strength of vinegar is below the government standard. The solids would also be low, as probably all the remainder of the principal constituents.

The following table made by the government shows the relations between the compositions of the apple and its pomace:

	Water	Solids	Invert Sugar	Sucrose	Free Malic Acid	Ash	Protein
Apples	80.88	19.12	9.86	2.17	0.41	0.32	0.44
Pomace	70.76	29.34	8.63	1.90	0.36	0.49	1.25

There still remains a good portion of the sugars in the pomace according to this analysis.

PURE CULTURE SYSTEM.

The pure culture system is being worked upon and has been stimulated from time to time by the finding

and isolation of acetic bacteria around and in vinegar factories. A table with a number of varieties has been given. The chief advantage gained by the pure culture system is, uniformity of product and perhaps better control. The chief reason for its non-adoption appears to be that the increased care and trouble of working with pure cultures do not, at present, meet with an adequate recompense in an increased value of the commodity.

EVAPORATION.

Evaporation in a vinegar factory is an important subject. One may smell the odor of acetic acid from a vinegar factory at a distance of a mile or more. Besides the loss of acetic acid, considerable loss of alcohol results. When vinegar is generated, much heat is evolved and herein lies a grave danger of an appreciable loss of both alcohol and acetic acid. The generators should have the strictest attention and their temperatures carefully controlled. Since the tanks for storage, the generators and the pipe lines are wood, they soak up a large quantity of vinegar.

The air currents passing thru the vinegar room evaporate, undoubtedly, a large amount.

It is claimed by one author that 15 to 30% of original alcohol present evaporates and is consequently a loss. Most vinegar makers agree that about 10% of the acetic acid evaporates. But no figures in either case are given to show upon what the conclusions are based.

The remedy lies in the most careful regulation of temperature of the generators to prevent loss of alcohol particularly. As much as possible of the fermenting should be done in winter as the generators may be run much faster than in summer. There should be no open streams of vinegar issuing from the generator to the pipe line. The pipe line should be made of glaze tile acid resisting. Experiments might be made to suck a current of air thru the generating rooms by aid of a wooden chute and attempting to catch the alcohol and acetic by washing with water or condensing by aid of water or artificial cooling.